

Attorney's Docket No.: 06618-457001 / CIT2986

REMARKS

Reconsideration and allowance of the above application are respectfully requested. A number of claims have been amended as indicated. No new matter is added. Attached is a marked-up version of the changes being made by the current amendment.

Applicant is working on the corrections of drawings as indicated in the Office Action. The corrected drawings will be filed at a later time.

The specification has been amended to correct the informalities as indicated in the Office Action. No new matter is added.

Claims 23, 27, 37, 38, 43, and 50 have been amended to overcome the objections. The amendment is clerical in nature and does not add new matter.

Claims 9 and 16 are fully supported by the original specification. The support for Claim 9 can be found in the original specification, e.g., on page 30, lines 19-21. Claim 16 is supported by the original specification at, e.g., page 4, lines 5+; page 9, lines 9+; page 18, line 19+; page 20, lines 10+; page 21, lines 9+; and page 22, lines 3+. Hence, the rejections under 35 USC 112, first paragraph should be withdrawn.

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Claims 12, 13, 17-19, 28-44, and 50 as amended are patentable under 35 USC 112, second paragraph. As for Claim 19, the comment in the Office Action is incorrect because the dimension of the mechanical oscillator has a unit in length, and thus, is not a scalar value. The inverse of the wavevector difference has a unit in length and thus can be compared to the dimension of the oscillator. Regarding Claim 34, the Office Action errs by stating that "no other electromagnetic polarization" has been claimed. In fact, two other electromagnetic polarizations are recited in Claim 34: the sample polarization and the probe polarization. Hence, the rejections for these claims should be withdrawn.

Now turning to rejections under 35 USC 102(b) and 103(a), Applicant respectfully suggests that all pending claims are patentable over the cited art.

Admittedly, Holczer discloses a force-detected MR system. However, Holczer's system is based on an entirely different technique. In Holczer, the probe-sample interaction is entirely restricted to magnetic moments manipulated by magnetic resonance and the respective forces are all associated with diagonal terms of the dipole moment operator, whose modulation is quadratic in the applied resonant fields.

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In stark contrast, the pending claims of this application are based on the force between the sample and probe near the difference in frequencies of respective off-diagonal polarizations in the sample and probe polarizations. These polarizations are linear in the applied optical (or Larmor frequency) fields. The following illustrate such difference in specific features in the independent claims.

Claim 1 as amended recites a sample polarization at a sample polarization frequency and a probe polarization at a probe frequency and further recites that "said probe polarization frequency and said sample polarization frequency are different from each other by an amount within a frequency response range of said mechanical oscillator." Holczer fails to disclose or suggest such features in the recited combination. Hence, Claim 1 is patentable over Holczer.

Claim 20 as amended recites "a radiation source to produce at least a probe excitation wave at a probe frequency and another excitation wave at a frequency different from said probe frequency but coherent with said probe excitation wave to produce an interference field." Holczer fails to disclose or suggest such features in the recited combination. Claim 20 further recites that "each mechanical oscillator responsive to said probe excitation wave to produce a probe polarization and

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said array of mechanical oscillators responsive to said interference field to produce polarizations representative of said interference field." Nothing in Holczer suggests such features in the recited combination. Claim 20 is patentable over Holczer.

Claim 28 as amended recites using a sample radiation wave at a sample frequency different from said probe frequency to interact with a sample and to produce a sample polarization, and that the sample radiation wave and the probe radiation wave are coherent to each other. Holczer fails to disclose or suggest such features in the recited combination. Holczer further fails to disclose other features in Claim 28, e.g., engaging a mechanical oscillator to at least one of said probe and said sample, wherein said mechanical oscillator moves in response to said interaction, wherein the difference between said probe frequency and said sample frequency is equal to or near a resonance frequency of said mechanical oscillator. Hence, Claim 28 is patentable over Holczer.

As for Claim 45, Holczer is completely silent on the recited feature of "using a detection radiation signal at a detection frequency to illuminate said oscillator to produce a wave mixing signal by light scattering at a scattered frequency

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which is a function of said sample frequency and said probe frequency." Hence, Claim 45 is patentable over Holczer.

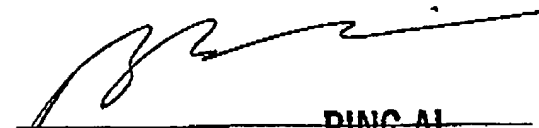
Similarly, Holczer fails to disclose or suggest "scanning the probe tip in proximity of a sample to interact with the sample with a sample polarization and to obtain measurements of different parts of the sample from a force on said probe tip as a function of a frequency difference between frequencies of the probe polarization and the sample polarization" in amended Claim 50. Therefore, Claim 50 is patentable over Holczer.

Other references by Ludeke and Takeda do not fill the above and other voids in the disclosure of Holczer. Hence, Holczer alone or in combinations with Ludeke and Takeda does not teach each feature in the pending claims. As such, the rejections under either 35 USC 102(b) or 35 USC 103(a) are not supported by the cited prior art and should be withdrawn.


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Applicant asks that all claims be allowed. Please apply the fee for extension of time in filing this response and other charges or credits, if appropriate, to Deposit Account No. 06-1050.

Respectfully submitted,

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Version with markings to show changes madeIn the specification:

Paragraph beginning at page 10, line 22 has been amended as follows:

Equation (1) can have AC components if the time dependence of P_s includes a field at a frequency (ω_s) different from the frequency (ω_p) of the field responsible for the field gradient. This is the basis of proposals for ultrasensitive spectroscopy of trapped ions where the AC force is at the difference between two applied rf frequencies and is matched to one of the frequencies of the trapped ion motion. U. S. Patent No. 4,982,088 to Weitekamp et al., and Pizarro and Weitekamp, "Magnetic resonance of trapped ions by spin-dependent cyclotron acceleration", Bull. Magn. Reson. 14, 220-223 (1992). Another technique for magnetic resonance force microscopy creates the AC force at the Larmor frequency by spin-locking the transverse magnetization in the presence of a ferromagnetic particle, which provides a static field gradient. Sidles, "Noninductive detection of single-proton magnetic-resonance", Appl. Phys. Lett. 58, 2854-2856 (1991). If either the sample or the ferromagnetic particle is bound to a cantilever with a

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mechanical resonance close to the Larmor frequency, its harmonic motion will be resonantly driven. Related magnetic resonance methods using time-dependent longitudinal magnetization have been demonstrated and show great promise for extending spin spectroscopies to micron scale and below. Sidles, "Magnetic-resonance force microscopy", Rev. Mod. Phys. 67, 249-265 (1995), Leskowitz et al., "Force-detected magnetic resonance without field gradients", Sol. St. Nucl. Magn. Reson. 11, 73-86 (1998) and "Force-detected magnetic resonance without field gradients", Bull. Am. Phys. Soc. 44, 543 (1999), and U.S. Patent No. 6,100,687 issued from U.S. Patent Application No. 08/872,528, "Force-Detected Magnetic Resonance Independent of Field Gradients" by Weitekamp et al. [(to be issued)]. Single-spin designs have been proposed based on audiofrequency nanoscale cantilevers with force sensitivity at a level of attonewton/(Hz)^{1/2}.

Paragraph beginning at page 30, line 5 has been amended as follows:

An efficient strategy for obtaining and sorting out a large set of such distinct composite signals is based on the [Hadamard] Hadamard matrices, a linearly independent set of matrices each element of which is zero (off) or one (on). The

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elements of these matrices are assigned in one-to-one correspondence with each oscillator. A set of measurements is made, with each oscillator turned on or off according to the corresponding element of a different [Hadamard] Hadamard matrix. The [Hadamard] Hadamard transform deconvolves from this signal the signal from each oscillator, with the assumption that it contributed identically in each measurement in which it was on. Thus this transformed data set is an image of the underlying surface, or more generally of the environment of the oscillators, with each oscillator contributing a pixel.

Paragraph beginning at page 30, line 19 has been amended as follows:

The states indicated as on and off might differ only in the distance between the probe and the sample, controlled, for example, by piezoelectric or thermal expansion of the probe dimension perpendicular to the surface. Note that this same strategy could be used in cases where the detection did not involve an optically driven mechanical oscillator, but some other means of spectroscopy relying on near field enhancement. Both apertureless near-field scanning optical microscopy and surface-enhanced Raman spectroscopy are examples where the signal is light scattered by the surface species of interest

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enhanced by the presence of a nanoscale tip. [Hadamard]
Hadamard transform versions of these methods would be
advantageous in extending them to linear or planar arrays of
probes, thereby increasing sensitivity and throughput, while
retaining spatial resolution.

In the claims:

Claims 5, 27, 30 and 31 have been cancelled.

Claims 23, 27, 37, 38, 43, and 50 have been amended as
follows:

1. (Amended) A system, comprising:

a probe module, having a probe responsive to a probe
excitation field at a probe polarization frequency to produce a
probe polarization, a sample holder holding a sample which has a
sample polarization at a sample polarization frequency, and a
mechanical oscillator engaged to one of said probe and said
sample holder to move in response to an interaction between said
probe polarization and said sample polarization, wherein said
probe polarization frequency and said sample polarization
frequency are different from each other by an amount within a
frequency response range of said mechanical oscillator;

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a detection module to measure a response of said mechanical oscillator to produce a signal indicative of a property of the sample.

2. The system as in claim 1, wherein the detection module includes a detecting device that measures a displacement of said mechanical oscillator.

3. The system as in claim 2, wherein said detecting device includes a light source to produce a detection optical wave to illuminate at least a portion of said mechanical oscillator, a photodetector to receive scattered detection wave.

4. (Amended) The system as in claim 1, wherein said probe module produces a probe excitation radiation wave at [a] said probe polarization frequency to effectuate said probe excitation field and a sample excitation wave at [a] said sample polarization frequency [different from said probe frequency], wherein said sample is responsive to said sample excitation wave to produce said sample polarization [is caused by said sample excitation wave].

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5. (Canceled) The system as in claim 4, wherein said probe frequency and said sample frequency are different from each other by an amount within a frequency response range of said mechanical oscillator.

6. (Amended) The system as in claim 1 [5], wherein said amount is equal to or near a fundamental resonant frequency of said mechanical oscillator.

7. (Amended) The system as in claim 1 [5], wherein said amount is equal to or near a harmonic frequency of said mechanical oscillator.

8. (Amended) The system as in claim 4 [5], wherein said probe module includes a radiation source and both of said probe excitation wave and said sample excitation wave are originated from a common wave generated from said radiation source.

9. The system as in claim 8, wherein said radiation source includes a laser to produce one of said sample and said probe excitation waves, and wherein said probe module includes an acousto-optic modulator which modulates said laser to produce another of said sample and said probe excitation waves.

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10. (Amended) The system as in claim 8, wherein [the] an output of said radiation source is modulated at a modulation frequency to produce one of said probe excitation wave and said sample excitation wave.

11. The system as in claim 10, wherein the modulation frequency is about one half of the frequency difference between said sample and probe frequencies.

12. (Amended) The system as in claim 10[8], wherein [the output] an amplitude of the output is modulated.

13. (Amended) The system as in claim 10[8], wherein [the output] a polarization of the output is modulated.

14. The system as in claim 1, further comprising a feedback loop to maintain said mechanical oscillator at a resonance condition.

15. The system as in claim 1, wherein said probe module includes at least another probe.

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16. The system as in claim 1, further comprising a spacing monitor mechanism to monitor a spacing between said probe and said sample.

17. (Amended) The system as in claim 1, wherein said probe is spaced from the sample by less than one wavelength of radiation from the probe excitation field.

18. (Amended) The system as in claim 1, wherein said mechanical oscillator has a dimension less than one wavelength of radiation from the probe excitation field.

19. (Amended) The system as in claim 4 [1], wherein said mechanical oscillator has a dimension greater than one wavelength of radiation from the probe excitation radiation wave and wherein the inverse of a wavevector difference of [incident radiation] said probe excitation radiation and sample excitation waves is less than the inverse of a dimension of said mechanical oscillator.

20. (Amended) A system, comprising:
a radiation source to produce at least a probe excitation wave at a probe frequency and another excitation wave

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at a frequency different from said probe frequency but coherent with said probe excitation wave to produce an interference field;

a probe having an array of mechanical oscillators to receive said probe excitation wave and said interference field, each mechanical oscillator responsive to said probe excitation wave to produce a probe polarization and said array of mechanical oscillators responsive to said interference field to produce polarizations representative of said interference field;

a sample holder to hold a sample with a sample polarization in a proximity of said probe to expose the sample to fields produced by said probe polarizations so as to cause motion of said mechanical oscillators from interaction between the probe polarization and the sample polarization; and

a detector module to measure movements of said mechanical oscillators.

21. The system as in claim 20, further comprising a detection radiation source to produce a detection radiation wave to illuminate said mechanical oscillators, wherein said detector module collects and measures scattered detection radiation wave to determine movements of said mechanical oscillators.

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22. The system as in claim 20, further comprising a mechanism to turn on and off said mechanical oscillators individually.

23. (Amended) The system as in claim 22, wherein said mechanical oscillators are turned on and off individually according to a [Hademard] Hadamard matrix.

24. The system as in claim 20, wherein said sample holder is movable to shift said sample relative to said probe.

25. The system as in claim 20, said mechanical oscillators are modulated to write information in the sample.

26. The system as in claim 20, said mechanical oscillators are operated to retrieve information recorded in the sample.

27. (Canceled) The system as in claim 20, wherein said radiation produces at least another excitation wave at a frequency different said probe frequency but coherent with said probe excitation wave to produce an interference field over said mechanical oscillators, said mechanical oscillators responsive

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to said interference field to produce polarizations representative of said interference field.

28. (Amended) A method, comprising:

producing a probe polarization by exposing a probe formed of a polarizable material to a probe excitation field of a probe radiation wave at a probe frequency;

using a sample radiation wave at a sample frequency different from said probe frequency to interact with a sample and to produce a sample polarization, wherein the sample radiation wave and the probe radiation wave are coherent to each other;

placing [a] said sample with [a] said sample polarization in a field of said probe polarization to effectuate an interaction between the probe and the sample;

engaging a mechanical oscillator to at least one of said probe and said sample, wherein said mechanical oscillator moves in response to said interaction, wherein the difference between said probe frequency and said sample frequency is equal to or near a resonance frequency of said mechanical oscillator;
and

detecting motion of said mechanical oscillator to measure a property of said sample.

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29. The method as in claim 28, further comprising exposing said sample to a sample excitation field to produce said sample polarization.

30. (Canceled) The method as in claim 29, further comprising:

using a probe radiation wave at a probe frequency to effectuate said probe excitation field; and

using a sample radiation wave at a sample frequency different from said probe frequency to effectuate said sample excitation field, wherein said sample radiation wave and said probe radiation wave are coherent to each other.

31. (Canceled) The method as in claim 30, wherein the difference between said probe frequency and said sample frequency is equal to or near a resonance frequency of said mechanical oscillator.

32. (Amended) The method as in claim 28 [30], wherein the difference between said probe frequency and said sample frequency is equal to or near a harmonic frequency of a resonance frequency of said mechanical oscillator.

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33. The method as in claim 32, wherein said harmonic frequency is a second harmonic of the resonance frequency.

34. (~~Amended~~) The method as in claim 28 [29], further comprising using another electromagnetic polarization, different from said sample polarization and said probe polarization, to affect the motion of said mechanical oscillator.

35. The method as in claim 28, further comprising illuminating said mechanical oscillator with a detection radiation wave at a detection frequency and detecting a scattered detection radiation wave whose frequency is shifted from said detection frequency due to the sample and probe interaction.

36. The method as in claim 28, further comprising scanning said probe and said sample relative to each other to obtain an image of said sample.

37. (~~Amended~~) The method as in claim 28 [30], further comprising modulating a polarization or said probe frequency of said probe [excitation] radiation wave.

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38. (Amended) The method as in claim 28 [30], wherein said probe includes a tip which is less than one wavelength of said probe [excitation] radiation wave to allow evanescent coupling.

39. (Amended) The method as in claim 28, further comprising:

detecting motion of said mechanical oscillator to measure a property of said sample at a first time;

detecting motion of said mechanical oscillator to measure the property at a second time; and

correlating measurements from said first and said second times to determine the property.

40. The method as in claim 28, wherein said mechanical oscillator is engaged to said probe, and further comprising:

engaging a second probe to a second mechanical oscillator to measure the property of said sample; and

correlating measurements from said probe and said second probe to determine the property.

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41. The method as in claim 40, wherein said measurements from said probe and said second probe are performed at different times.

42. The method as in claim 40, wherein said measurements from said probe and said second probe are performed at the same time.

43. (~~Amended~~) The method as in claim 28, further comprising [measure] measuring the property of said sample a plurality of times when a parameter associated with excitation of said probe or sample is adjusted to have different values.

44. The method as in claim 28, wherein said interaction between said sample and said probe includes a dissipative interaction.

45. A method of nonlinear wave mixing, comprising:
 using a probe radiation wave at a probe frequency to excite a probe to produce a probe polarization;
 using a sample radiation wave at a sample frequency to excite a sample to produce a sample polarization;

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positioning said sample close to said probe to allow interaction;

engaging an oscillator to at least one of said sample and said probe so that said oscillator moves in response to said interaction; and

using a detection radiation signal at a detection frequency to illuminate said oscillator to produce a wave mixing signal by light scattering at a scattered frequency which is a function of said sample frequency and said probe frequency.

46. The method as in claim 45, wherein the difference between said probe frequency and said sample frequency is equal to or near a fundamental resonance frequency of said oscillator.

47. The method as in claim 45, wherein the difference between said probe frequency and said sample frequency is equal to or near a harmonic frequency of a resonance frequency of said oscillator.

48. The method as in claim 45, further comprising using the same probe radiation wave to excite a second probe to interact with the sample, wherein the radiation from the second probe is coherent with the radiation from the probe.

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49. The method as in claim 45, wherein said scattered frequency is equal to a frequency difference between said sample frequency and said probe frequency plus or minus said probe frequency.

50. (~~Amended~~) A method, comprising:

using a probe excitation wave to illuminate an optically polarizable probe tip, the tip responsive to produce a probe polarization; and

scanning the probe tip in [the] proximity of a sample to interact with the sample with a sample polarization and to obtain measurements of different parts of the sample from a force on said probe tip as a function of a frequency difference between frequencies of the probe polarization and the sample polarization],

wherein incident light scattered from a combination of sample and tip is modulated in its polarization or frequency as it is scanned through electromagnetic resonances of the sample].